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STATISTICS.—*The frequency distribution of scientific productivity.* ALFRED J. LOTKA. Metropolitan Life Insurance Company, New York.

It would be of interest to determine, if possible, the part which men of different calibre contribute to the progress of science.

Considering first simple volume of production, a count was made of the number of names, in the decennial index of Chemical Abstracts 1907–1916, against which appeared 1, 2, 3 . . . . entries. Names of firms (e.g. Aktiengesellschaft, etc.) were omitted from reckoning, since they represent the output, not of a single individual, but of an unknown number of persons. The letters A and B of the alphabet only were covered. These were treated both separately and in the aggregate, with the results shown in the table and in figures 1 and 2 below.

A similar process was also applied to the name index of Auerbach's Geschichtstafeln der Physik (J. A. Barth, Leipzig, 1910) which cover the entire range of history up to and including the year 1900. In this case we obtain a measure not merely of volume of productivity, but account is taken, in some degree, also of quality, since only the outstanding contributions find a place in this little volume, with its 110 pages of tabular text. The figures and relations thus obtained are shown in the table and in figures 1 and 2.

On plotting the frequencies of persons having made 1, 2, 3 . . . . contributions, against these numbers 1, 2, 3 . . . . of contributions, both variables on a logarithmic scale, it is found that in each case the points are rather closely scattered about an essentially straight line having a slope of approximately two to one. The approach to this ratio is particularly close in the case of the data taken from Auerbach's

TABLE 1.—FREQUENCY DISTRIBUTION OF SCIENTIFIC PRODUCTIVITY

NUMBER OF CONTRIBUTIONS n	NUMBER OF PERSONS MAKING STATED NUMBER OF CONTRIBUTIONS				PER CENT OF TOTAL					
	Chemical Abstracts			Auerbach's tables entire alphabet	Chemical Abstracts				Auerbach's tables	
					Observed			Computed[1]	Observed	Computed[1]
	Letter A	Letter B	A + B		A	B	A + B	A + B	Entire alphabet	
Total	1,543	5,348	6,891	1,325						
1	890	3,101	3,991	784	57.68	57.98	57.92	56.69	59.17	60.79
2	230	829	1,059	204	14.91	15.50	15.37	15.32	15.40	15.20
3	111	382	493	127	7.19	7.14	7.15	7.12	9.58	6.75
4	58	229	287	50	3.76	4.28	4.16	4.14	3.77	3.80
5	41	143	184	33	2.66	2.67	2.67	2.72	2.49	2.43
6	42	89	131	28	2.72	1.66	1.90	1.92	2.11	1.69
7	20	93	113	19	1.30	1.74	1.64	1.44	1.43	1.24
8	24	61	85	19	1.56	1.14	1.23	1.12	1.43	0.95
9	21	43	64	6	1.36	0.80	0.93	0.90	0.45	0.75
10	15	50	65	7	0.97	0.93	0.94	0.73	0.53	0.61
11	9	32	41	6	0.58	0.60	0.59	0.61	0.45	0.50
12	11	36	47	7	0.71	0.67	0.68	0.52	0.53	0.42
13	6	26	32	4	0.39	0.49	0.46	0.45	0.30	0.36
14	7	21	28	4	0.45	0.39	0.41	0.39	0.30	0.31
15	3	18	21	5	0.19	0.34	0.30	0.34	0.38	0.27
16	4	20	24	3	0.26	0.37	0.35	0.30	0.23	0.24
17	4	14	18	3	0.26	0.26	0.26	0.27	0.23	0.21
18	5	14	19	1	0.32	0.26	0.28	0.24		
19	3	14	17	0	0.19	0.26	0.25	0.22		
20	6	8	14	0	0.39	0.15	0.20	0.20		
21	0	9	9	1	—	0.17	0.13	0.18		
22	2	9	11	3	0.13	0.17	0.16	0.17		
23	4	4	8	0	0.26	0.07	0.12	0.15		
24	4	4	8	3	0.26	0.07	0.12	0.14		
25	0	9	9	2	—	0.17	0.13	0.13		
26	3	6	9	0	0.19	0.11	0.13	0.12		
27	1	7	8	1	0.06	0.13	0.12	0.11		
28	2	8	10	0	0.13	0.15	0.15	0.11		
29	2	6	8	0	0.13	0.11	0.12	0.10		
30	2	5	7	1	0.13	0.09	0.10	0.09		
31	0	3	3	0	—	0.06	0.04			
32	0	3	3	0	—	0.06	0.04			
33	3	3	6	0	0.19	0.06	0.09			
34	1	3	4	1	0.06	0.06	0.06			
35	0	0	0	0	—	—	—			
36	0	1	1	0	—	0.02	0.01			
37	0	1	1	1	—	0.02	0.01			
38	1	3	4	0	0.06	0.06	0.06			
39	0	3	3	0	—	0.06	0.04			
40	1	1	2	0	0.06	0.02	0.03			
41	0	1	1	0	—	0.02	0.01			

TABLE 1—CONTINUED.

NUMBER OF CONTRIBUTIONS n	NUMBER OF PERSONS MAKING STATED NUMBER OF CONTRIBUTIONS				PER CENT OF TOTAL					
	Chemical Abstracts			Auerbach's tables entire alphabet	Chemical Abstracts				Auerbach's tables	
					Observed			Computed[1]	Observed	Computed[2]
	Letter A	Letter B	A + B		A	B	A + B	A + B	Entire alphabet	
42	0	2	2	0	—	0.04	0.03			
43	0	0	0	0	—	—	—			
44	0	3	3	0	—	0.06	0.04			
45	0	4	4	0	—	0.07	0.06			
46	1	1	2	0	0.06	0.02	0.03			
47	0	3	3	0	—	0.06	0.04			
48	0	0	0	2	—	—	—			
49	0	1	1		—	0.02	0.01			
50	1	1	2		0.06	0.02	0.03			
51	0	1	1		—	0.02	0.01			
52	0	2	2		—	0.04	0.03			
53	0	2	2		—	0.04	0.03			
54	0	2	2		—	0.04	0.03			
55	2	1	3		0.13	0.02	0.04			
56	0	0	0		—	—	—			
57	0	1	1		—	0.02	0.01			
58	0	1	1		—	0.02	0.01			
59–60	0	0	0		—	—	—			
61	0	2	2		—	0.04	0.03			
62–65	0	0	0		—	—	—			
66	0	1	1		—	0.02	0.01			
67	0	0	0		—	—	—			
68	0	2	2		—	0.04	0.03			
69–72	0	0	0		—	—	—			
73	0	1	1		—	0.02	0.01			
74–77	0	0	0		—	—	—			
78	0	1	1		—	0.02	0.01			
79	0	0	0		—	—	—			
80	1	0	1		0.06	—	0.01			
81–83	0	0	0		—	—	—			
84	0	1	1		—	0.02	0.01			
85–94	0	0	0		—	—	—			
95	0	1	1		—	0.02	0.01			
96–106	0	0	0		—	—	—			
107	1	0	1		0.06	—	0.01			
108	0	0	0		—	—	—			
109	0	1	1		—	0.02	0.01			
110–113	0	0	0		—	—	—			
114	0	1	1		—	0.02	0.01			
115–345	0	0	0		—	—	—			
346	1	0	1		0.06	—	0.01			

[1] According to $f = 56.69/n^{1.888}$.

[2] According to $f = 600/\pi^2 n^2$.

tables. Determined by least squares, the slope of the curve to Auerbach's data, as determined from the first 17 points,[1] was found to be 2.021 ± 0.017. Similarly, the slope for the data in the Chemical Abstracts, letters A and B jointly, as determined from the first thirty points, came out as 1.888 ± 0.007. The general formula for the relation thus found to exist between the frequency y of persons making x contributions is

$$x^n y = \text{const} \tag{1}$$

For the special case that $n = 2$ (inverse square law of scientific productivity) the value of the constant in (1) is found as follows:

$$y_1 = \frac{c}{1^2} \tag{2}$$

$$y_2 = \frac{c}{2^2} \tag{3}$$

$$y_n = \frac{c}{n^2} \tag{4}$$

$$\sum_1^\infty y = c\left(\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \ldots\ldots\ldots\right) \tag{5}$$

$$= c \sum_1^\infty \frac{1}{x^2} \tag{6}$$

$$= c\,\frac{\pi^2}{6} \tag{7}[2]$$

$$c = \frac{6}{\pi^2} \sum_1^\infty y \tag{8}$$

But, since y is a frequency, the summation $\sum_1^\infty y$ gives unity.

Then finally

$$c = \frac{6}{\pi^2} \tag{9}$$

$$= \frac{6}{9.87} \tag{10}$$

$$= 0.6079 \text{ or } 60.79 \text{ per cent} \tag{11}$$

[1] Beyond this point fluctuations become excessive owing to the limited number of persons in the sample.

[2] See, for example, K. KNOPP, *Theorie und Anwendung der unendlichen Reihen:* 239, 1924 or J. L. COOLIDGE, *Mathematical Theory of Probability:* 22, 1925. For method of summation when exponent is fractional, see WHITTAKER and ROBINSON *Calculus of Observations:* 136, 1924. Exponent 1.888 thus gives the value $c = 0.5669$ appearing at the top of ninth column in Table 1.

Thus, according to the inverse square law, the proportion of all contributors who contribute a single item should be just over 60 per cent. In the cases here examined the actual proportion of this class to the whole was 59.2 per cent in Auerbach's data (1325 contributors), 57.7 per cent in the Chemical Abstracts under initial A (1543 contributors) 57.98 under letter B (5348 contributors) and 57.9 under letters A and B jointly (6891 contributors).

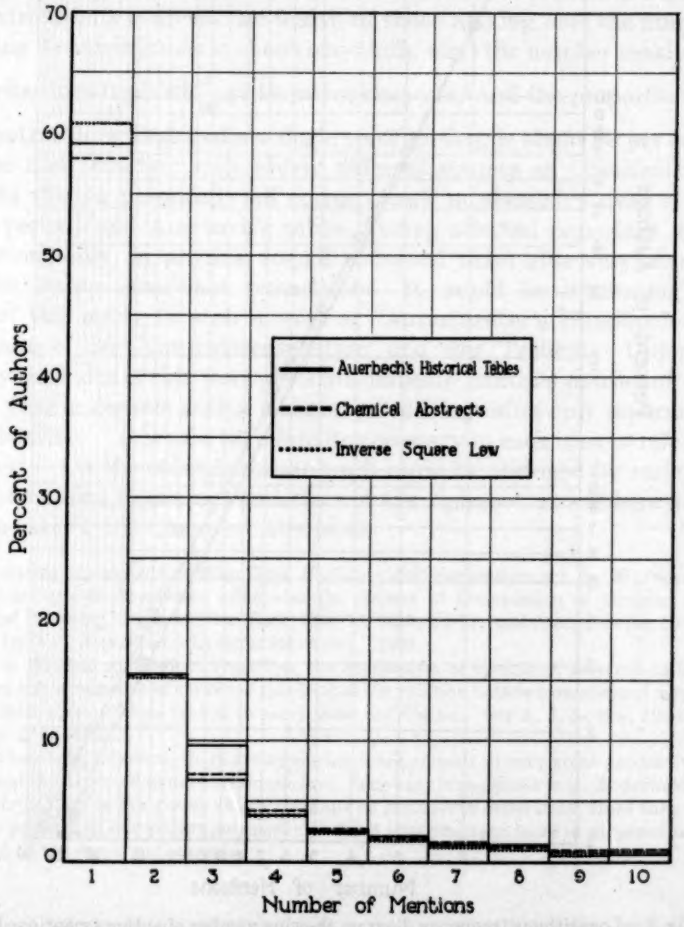


Fig. 1.—Frequency diagram showing per cent of authors mentioned once, twice, etc., in Auerbach's Geschichtstafeln der Physik, entire alphabet, and in the decennial index of Chemical Abstracts 1907–1916, letters A and B. The dotted line indicates frequencies computed according to the inverse square law.

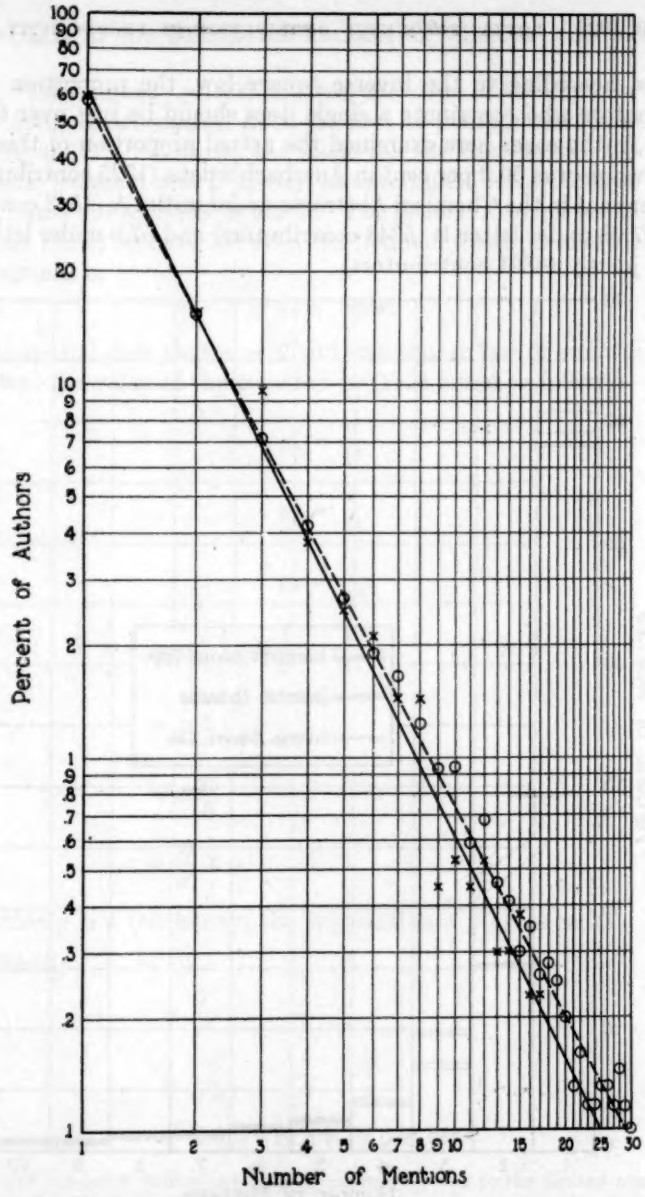


Fig. 2.—Logarithmic frequency diagram showing number of authors mentioned once, twice, etc., in Auerbach's tables (points indicated by crosses), and in Chemical Abstracts, letters A and B (points indicated by circles). The fully drawn line indicates points given by inverse square law, exponent = 2; the line of dashes corresponds to exponent 1.89.

Frequency distributions of the general type (1) have a wide range of applicability to a variety of phenomena,[3] and the mere form of such a distribution throws little or no light on the underlying physical relations.[4] The fact that the exponent has, in the examples shown, approximately the value 2 enables us to state the result in the following simple form:

In the cases examined it is found that the number of persons making 2 contributions is about one-fourth of those making one; the number making 3 contributions is about one-ninth, etc.; the number making n contributions is about $\frac{1}{n^2}$ of those making one;[5] and the proportion, of all contributors, that make a single contribution, is about 60 per cent.

The fact that two such widely different sources as Chemical Abstracts (listing practically all current work in chemistry over a ten year period) and Auerbach's tables (listing selected important contributions only, in physics, for all historical time) give very similar results, seems somewhat remarkable. It would be interesting to extend this study to such a work as Darmstaedter's Handbuch der Geschichte der Naturwissenschaften und der Technik. Unfortunately the index of this work does not indicate multiple entries of the same year under one author's name, but distinguishes only separately dated entries. It would therefore be necessary in each case to refer to the text. On the other hand the work could be abridged by restricting the inquiry to one or two letters of the alphabet, as was here done in the case of the Chemical Abstracts.

[3] Compare especially CORRADO GINI, *Biblioteca dell' Economista*, ser. 5a, 20: *Indici di concentrazione e di dipendenza*. See also the Report of Commission of Housing and Regional Planning, State of New York, Jan. 11, 1926: 59–73; and *Income in the United States*, by W. I. KING and others; 2: 344 et seq. 1922.

[4] C. J. WILLIS' conclusions regarding the mechanism of evolution, inferred as they are from the occurrence of curves of this type in the relation between numbers of species and genera, seem for this reason to carry little conviction. See A. J. LOTKA, *Physical Biology:* 311. 1925.

[5] Fortunately, however, there are somewhat more persons of very great productivity than would be expected under this simple law. The very high figures (e.g., Abderhalden, 346 contributions in ten years) should perhaps be considered separately, since they are not the product of one person unassisted. Joint contributions have in all cases been credited to the senior author only.

GEOLOGY.—*Geology of the Guantánamo Basin, Cuba.*[1] N. H. DARTON, U. S. Geological Survey.

During the Spring of 1916 I had the opportunity to examine the Guaso Valley and some of the surrounding ridges in the central part of Oriente District, Cuba, in the general vicinity of Guantánamo. The purpose of my visit was to ascertain the prospects for artesian water desired for irrigation by one of the large sugar companies and for this it was necessary to determine the stratigraphic succession and structure of the region. As there is nothing on record regarding these features and I also obtained some important paleontologic data it is believed that the results will be of interest. It was supposed that much of the area was covered by a tropical jungle but I found that exposures were extensive and while roads were not good, nearly all points could be reached easily on horse.

TOPOGRAPHY

As shown in the map, figure 1, the Guantánamo basin is a broad valley sloping to the south where it is flooded by tide water of the Bay of Guantánamo and the Enseñada de Joa. The valley heads to the north in a high ridge called Sierra Guaso and is bordered on the east by Sierra Maquay[2] and in part on the west, by Sierra Cañada. It is about 25 miles long and 15 miles wide. Much of the area is smooth or gently undulating but to the northward there are low terraced ridges between the shallow valleys of the streams. These streams head in the highlands to the north and northwest and flow south in nearly parallel courses to tide water. Guantánamo River, which rises far to the northwest, flows across the southeastern corner of the basin and empties into Guantánamo Bay near its mouth. The streams nearly all have steep banks 5 to 40 feet high, and most of them are deepening their channels into the rocks. But little alluvium is being deposited excepting in the bays and estuaries below tide water level.

THE ROCKS

General succession.—The oldest formation in the region consists of schists and other crystalline rocks which constitute the ridge on the sea shore at the Naval Station and the central and northern part of Sierra Guaso. I did not study these rocks but they appear to be simi-

[1] Received May 11, 1926.

[2] Named from shells and not from the Maguey plant.

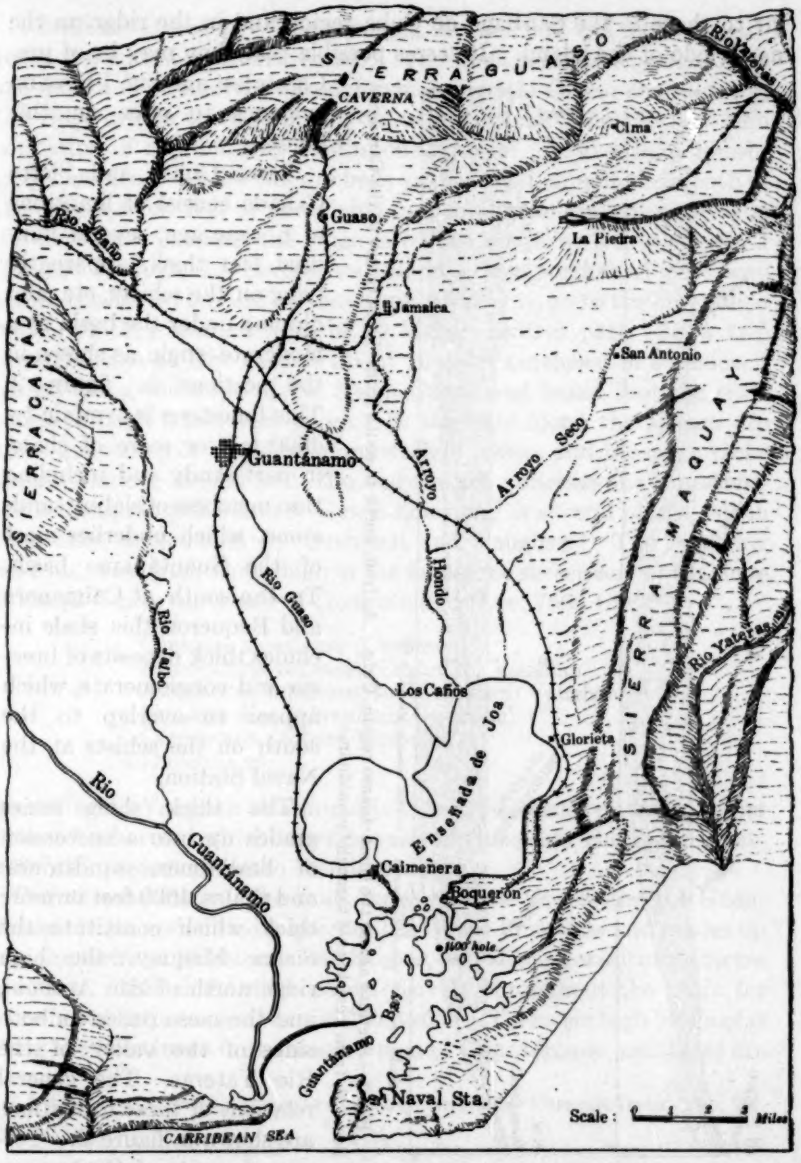


Fig. 1.—Sketch map of the Guantánamo region compiled from various sources, with additions by N. H. DARTON.

lar to those in the Santiago de Cuba region and in the ridge on the north side of the island. It seems possible that they may be of pre-Cambrian age but I have no evidence to offer on this point.

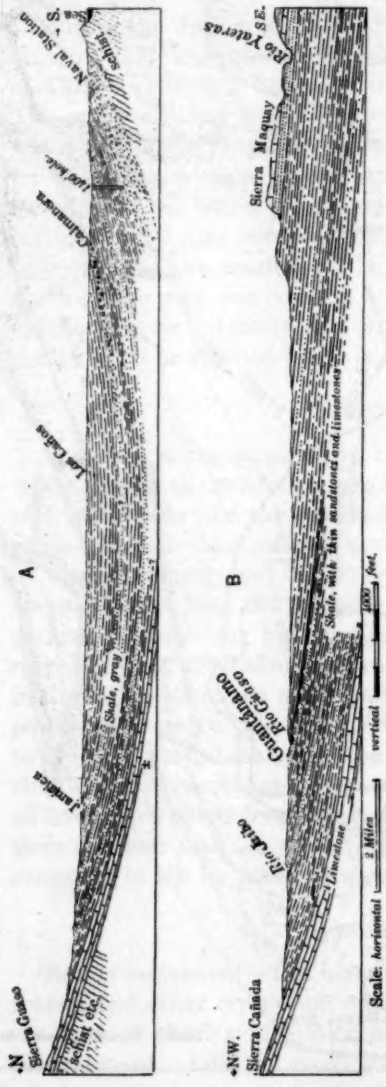


Fig. 2.—Sections across the Guantánamo region, Cuba. A, from north to south from Sierra Guaso to the Carribean Sea. B, from west to east through Guantánamo.

Sierra Guaso and Sierra Cañada consist of limestone of Eocene age, several hundred feet thick, apparently lying on the schists, etc. and dipping under the basin at a moderate angle as shown in the sections in figure 2. This limestone is overlain by 4000 feet or more of shale, in part sandy and including thin members of slabby sandstone, which underlies most of the Guantánamo basin. To the south at Caimanera and Boqueron this shale includes thick deposits of breccia and conglomerate, which appear to overlap to the south on the schists at the Naval Station.

The thick shale series grades up into a succession of limestones, sandstones, and shales, 1000 feet or more thick which constitute the Sierra Maquay, the high ridge north of San Antonio, and the mesa region on both sides of the valley of the Rio Yateras. The general relations of these formations are shown in figure 2. Terrace deposits of Quaternary age occur in the Guantánamo basin and along the sea margin are terraces of coral, one very persistent one, the "Seboruco," extending to tide level.

The Guaso limestone.—The principal limestone of the region constitutes the cuesta of Sierra Guaso. The most notable exposure is at the mouth of the cavern through which the Rio Guaso comes out of the ridge where there is a canyon with vertical walls 150 feet high consisting of a practically continuous body of massive, light bluish-gray limestone. A few impure beds are included, and at the mouth of the cavern a few feet of underlying buff sandstone are exposed. The dip here and all along the ridge is to the south at a low angle. I traveled through the cavern and made a trip northward part way across the sierra, but did not have opportunity to go to the crystalline rocks, which I learned were in its higher central part. In a trip through Cima to Rio Yateras about 10 miles northeast of Jamaica, I passed along the slope of the Sierra Guaso and found that the river comes through it in a deep gorge. In the flats along the stream are great quantities of bowlders of crystalline schists and intrusive rocks of many kinds, derived from the body which underlies the limestone.

I collected fossils from the Guaso limestone at several places, which have been determined by Cushman and Vaughan.[3] The following were obtained from strata high in the limestone succession on the slope of Sierra Guaso northeast of Guantánamo (Loc. 7666 USGS).

Conulites americana (Cushman)
Discocyclina cubensis (Cushman) Vaughan
Asteriacites subtaramellei (Cushman) Vaughan
Lepidocyclina subraulinii (Cushman)
Carpenteria proteus (Cushman)
Linderina sp.

According to Vaughan this fauna is "clearly Eocene, probably upper Eocene" a horizon which is widespread in Cuba and Haiti and apparently also present in Santo Domingo.

Guantánamo shale.—The thick series of shale underlying the Guantánamo basin undoubtedly overlies the Guaso limestone and grades up into the series of limestones, sandstones, and shales constituting Sierra Maquay. This shale outcrops extensively throughout the basin for there is but little cover of surficial deposits. There are high bluffs of it along the Rio Guaso in the eastern part of Guantánamo, and there are

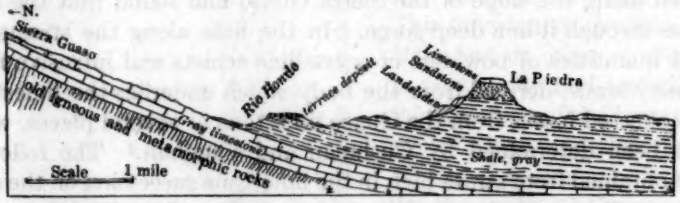
[3] J. A. CUSHMAN, *Fossil foraminifera from the West Indies:* Carnegie Instn., Pub. 291. 21–71, pls. 1–15, 1919.

———, *The American species of Orthophragmina and Lepidocyclina:* U. S. Geol. Survey Prof. Paper **125**: 39–105, pls. 7–35, 1920.

T. W. VAUGHAN, *American and European Tertiary larger foraminifera:* Geol. Soc. Amer. Bull. **36**: 785–822, pls. 30–36, 1925.

many exposures of it along other streams. Apparently it extends far northwest up the Rio Bano Valley and westward, for I noted it along the railroad to San Luis, and to Jiguani where the underlying limestone comes up. Shale of the same character also outcrops at Antilla. The formation is well exposed in the wide flats about the Enseñada de Joa, notably near Glorieta and on the railroad cuts south of that place toward Boqueron.

The relations of this formation to the Guaso limestone were examined north of Guaso, near Cima, and at the foot of Sierra Cañada. At all of these places there is perfect conformity, but an abrupt change from limestone to shale. Superposition of the latter is evident throughout.



[Fig. 3.—Section from Sierra Guaso southeastward through La Piedra.

The thickness of the Guantánamo shale is about 4,000 feet, judging by width of outcrops and scattered dip determinations. In a section passing through Guantánamo, as shown in Section B, figure 2, the dips average from 6 to 10 degrees in the western part of the basin and about 5 degrees in the eastern part. Near Cima, however, where the dips are about 10 to 12 degrees, the thickness either is considerably less, some of the beds are cut off by a fault, or the base of the overlying formation begins at a lower horizon. The diminished thickness is shown in figure 3. The predominant material of the formation is brownish-gray shale in large part somewhat sandy and soft. Thin beds of brown to dirty gray sandstone occur at intervals, and thin beds of limestone appear at various horizons, especially near the middle of the formation. Some of the sandstone members are conspicuous in the town of Guantánamo and others at a lower horizon outcrop extensively on the east bank of the Rio Jaibo a few miles west of Guantánamo. A 10-foot bed of coarse arkose was noted 4 miles southeast of Guantánamo underlying fine-grained sandy limestone and underlain by dark shale with thin layers of limestone. The dip here is N. E. 70°. Other thin beds of limestone are conspicuous about Jamaica and in the bed of Rio Guaso in the northwestern part of Guantánamo.

In general the material of the formation becomes finer grained to the north. The clay of this shale is the cause of the very muddy condition of the basin during the rainy season when most of the roads become impassable for vehicles.

Some foraminifera were found in thin limestone lenses in the lower part of this formation at Cima northeast of Jamaica and in upper beds on the north slope of La Piedra. The latter were determined as follows by Cushman.[4]

Lepidocyclina schlumbergeri (Lemoine and Douvillé)
Lepidocyclina marginata (Michelotti)
Lepidocyclina sumatrensis (H. B. Brady)
Carpenteria americana (Cushman)

The specimen of *Lepidocyclina morgani* included in his list came from Jigue de la Argolla and Vaughan[5] on reëxamination of the collection believes that *L. marginata* and *L. sumatrensis* also came from other localities. Vaughan states that the name *L. dilatata* of Michelotti has priority over *L. schlumbergeri* and he finds that the genus is also represented in the collection by a new stellate species, soon to be described, and several other species. He adds to the list the following:

Orbulina? sp.
Globergerina sp.
Amphistegina sp.
Heterostegina sp.
and a coral
Orbicella imperatoris (Vaughan)

Vaughan states that this fauna is either Oligocene, probably high Oligocene, or very low Miocene. An Aquitanian age is not improbable. The coral *Orbicella imperatoris* indicates a high horizon. However, the fauna is a new one for the West Indies and it is probably for that reason that so few of the species can be identified.

Conglomerate of Boqueron and Caimanera.—The ridge and bluffs at Boqueron and Caimanera consist of a thick deposit of coarse dark conglomerate that appears to be in the midst of the shale series. The Boqueron ridge shows about 50 feet of the rock in thick irregular beds, most of it loosely cemented, and dipping S. E. at angles varying from 78° to 10°. Bowlders from 1 to 3 inches in diameter predominate and they consist of quartzite and a considerable variety of diorites and other igneous rocks. Most of them are round, but some are angular

[4] Op. cit., Prof. Paper 125.
[5] Personal communication.

and subangular. The following section shows the relations at this place.

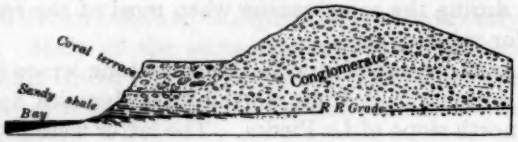


Fig. 4.—Section of bluff at Boqueron on Guantánamo Bay, Cuba.

A bench or terrace on the west slope of the conglomerate ridge is occupied by an uplifted coral reef, but below this a dark sandy shale outcrops showing that the conglomerate is underlain by this material. Not far east of Boqueron are shales and sandstones which doubtless overlie the conglomerate and constitute the slopes of the west side of the southern extension of the Sierra Maquay. These shales are exposed in the deep railroad cuts along the bay shore between Boqueron and Glorieta.

The conglomerate in the bluff at Caimanera, across the bay from Boqueron, is similar to the rock at the latter place and apparently part of the same deposit. The beds here dip north at an angle of 8 degrees, with strike toward Boqueron. At one locality in the southern part of Caimanera the conglomerate is seen to be underlain by sandy shale as at Boqueron. Possibly the conglomerate extends under the low land to the west, but I did not have opportunity to trace it. It is my belief that the deposit marks the course of a stream which flowed across the region when the muds constituting the shale that now underlies the basin were being deposited.

A somewhat similar conglomerate was reported in a 1400-foot boring a mile and a half south of Boqueron sunk for water in 1906 at the first location of the U. S. Naval Station. The record was as follows: The first 141 feet was reported as mostly conglomerate some of which was termed "shale conglomerate" or "slate conglomerate." Next below are 300 feet of shales with several thin beds of conglomerate, some of which are reported as "sand conglomerate" and "lime conglomerate." Below 441 feet all was shale, of which the lower 90 feet were of lighter tint. A trace of coal was mentioned at 273 feet.

As the dip is to the east and northeast in this vicinity the beds in this hole doubtless underlie the conglomerate exposed at Boqueron and Caimanera. The relation to the strata in the region farther south is not known because the structure was not ascertained. Shale outcrops on the east side of Hospital Key, with dip S. 20°, and the rocks

about the U. S. Naval Station dip north, facts which indicate a shallow syncline to the south with a low anticline between Hospital Key and the 1400 foot boring.

Maquay formation: The prominent ridge known as Sierra Maquay consists of a succession of sandstones and limestones overlying the Guantánamo shale. These strata also constitute La Piedra and the ridge of which that feature is a part and they occupy a wide area in the high mesas and ridges east of Rio Yateras. There is considerable shale between the harder strata and apparently the succession of beds varies considerably from place to place. A basal member of about 40 feet of soft massive sandstone, with many hard layers 6 to 12 inches thick, appears in the lower slopes east of San Antonio and is well exposed in a railroad cut about one-half mile east of that plazita. Next above are softer sandstones with intercalated beds of shale and limestone which extend south along the western front of Sierra Maquay and northwestward to La Piedra toward which they rise on a low dip. On the trail passing through the gap in Sierra Maquay east of Glorieta I found 400 feet or more of the light-gray massive shales extending far up the slope to a thick cap of the gray slabby sandstones including thin beds of limestones, at the top of the ridge. These beds dip east at a low angle and constitute the cuesta that slopes down toward Rio Yateras. The valley of this fine stream is a deep one with high mesas of Maquay formation on its east side and it becomes a canyon a short distance south of the point at which the trail reaches it east of Glorieta.

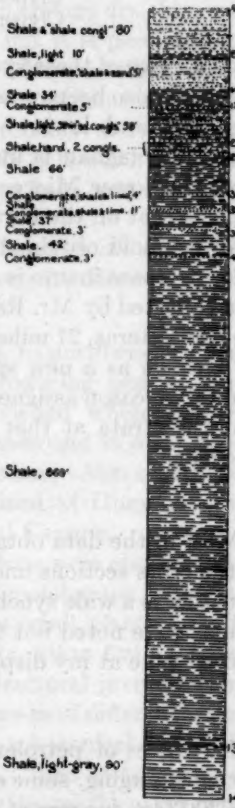


Fig. 5.—Record of deep boring 1½ miles south of Boqueron, Cuba.

At a locality called El Jigue de la Argolla about 2 miles northeast of San Antonio fossil echinoids, called "estrellas" by the people, have been obtained by Mr. Charles Ramsden of Guantánamo. Some of

these kindly furnished by Mr. Ramsden have been determined as follows by Dr. Jackson:[6]

Echinolampas anguillae (Cotteau)
Clypeaster concavus (Cotteau)
Clypeaster placentoides, new species

The first two of these species were noted by Vaughan in Anguilla and they have also been reported from Antigua, in beds regarded as middle Oligocene and lower Miocene and while "the evidence is inconclusive"[7] Vaughan is inclined to regard the echini at El Jigue de la Argolla as lower Miocene probably near the Anguilla horizon and the same as that on the north slope of La Piedra.

An echinoid obtained by Mr. Ramsden from Mount Toro, northwest of Guantánamo is a new species of Clypeaster. Another specimen collected by Mr. Ramsden from high on the slope of the valley of the Rio Yateras, 21 miles northeast of Guantánamo, has been described by Jackson as a new species *Cardiaster cubensis*, and for some unaccountable reason assigned to the Cretaceous.[8] It is probable, however, that the strata at that locality are either upper Oligocene or lower Miocene.

STRUCTURE

Most of the data obtained as to structure of the region are set forth in the cross sections and the descriptions of the strata. The general structure is a wide syncline opening to the east. Various minor undulations were noted but their relations could not be worked out in the limited time at my disposal.

PETROLEUM

No traces of petroleum were observed. While the prospects are not encouraging, some of the sandstone members in the lower part of the 300 feet or more of the Guantánamo shale might possibly contain this material.

[6] R. T. JACKSON, *Fossil Echini of the West Indies:* Carnegie Instn., Pub. 306, 1922.

[7] Personal communication from manuscript in preparation.

[8] R. T. JACKSON, *op. cit.*, pp. 5, 12, 69-70, G. STEFANINI, *Relations between American and European Tertiary Echinoid faunas:* Geol. Soc. Amer. Bull. 35: 845-846, 1925, questions this assignment to the Cretaceous and suggests that the age is Miocene.

ARTESIAN WATER

It seems unlikely that the sandstone members in the shale series under Guantánamo basin contain any large amount of water that would rise to or above the surface. These members are thin, mostly muddy and have very small outcrop areas but it is possible that in some places they might afford a local supply. It seems likely however, that there is some chance for water in the conglomerate near the Naval Station where the coarse deposits probably abut against the schists. It is also possible that if the 1400-foot hole south of Boqueron had been deeper it might have reached coarse beds containing water.

BOTANY.—*New species of cotton plants from Sonora and Sinaloa, Mexico.* O. F. COOK and J. W. HUBBARD, Bureau of Plant Industry.[1]

A brief visit was made in December, 1925, to northwestern Mexico to study the native cottons and rubber-producing plants. In the vicinity of Guaymas two localities were visited where *Gossypium davidsonii* grew in abundance along dry washes and in open shrubby vegetation, much as Thurberia grows in Arizona. Also several forms of the native door-yard cottons were obtained at Guaymas and in the Yaqui Valley, at Esperanza, Cocorit, and Cajeme.

Most of the data regarding the native cottons were obtained at Los Mochis, Sinaloa, between San Blas and Topolobampo. Several of the native species had been collected and a small planting made at Los Mochis by Dr. W. W. Morrill, formerly State Entomologist of Arizona, and more recently engaged in agricultural investigations in Mexico. Dr. Morrill had observed a wide range of differences among the native cottons, and invited us to make a botanical study of the collection that he had grown at Los Mochis. Also he suggested that we stop at Guaymas and in the Yaqui Valley, to see the other types of native cottons that he had noted in those districts.

The classification of the species of Gossypium presents several difficulties that are not apparent on the surface, but are more appreciated as wider knowledge and experience are gained. One of the chief difficulties is that the cotton plants and their relatives have a protean flexibility of response to different conditions of growth. Such changes of characters often extend beyond any reasonable prospect of associating the members of the same progeny, if the origin of the seed is not

[1] Received May 5, 1926.

definitely known. The size of the plants, the habits of growth, the forms, textures and surfaces of the leaves and involucral bracts; the sizes and shapes of the bolls, numbers of locks, and even the seed and lint characters, have been profoundly altered in some of the cottons brought from tropical countries, when planted for the first time in the United States.

Other difficulties in classification arise from differences of age and of seasonal or cultural conditions, complicated also by the variability and diversity that are usually to be found in the leaves and other organs of the same individual plant. The juvenile leaves are different from the adult leaves, the stalk leaves different from the branch leaves, and the sun leaves different from the shade leaves. Thus a very wide range of sizes, forms and textures of leaves, bracts, and bolls, may be found on any large plant. Yet with side by side comparisons of living plants and judicious selection of material, it becomes possible to recognize and formulate contrasting characters. Without such comparisons the characters remain too indefinite and intangible to be used for purposes of diagnosis.

Much of the herbarium material of Gossypium has been assembled with no recognition or purpose of showing the distinctive characters of the species, and the association of such material into species is largely speculative or arbitrary. The usual herbarium specimen is a part of a fruiting branch with a flower, but showing little of the range of characters, even of the leaves and involucres. The characters of the fresh unopened bolls, which afford some of the most distinctive features, are difficult to preserve, and usually disappear in the dried specimens.

Finally, the task of classification is complicated by the wealth of plant types, whether species, varieties, or hybrids, of which it is necessary to take account. Missionaries and traders have carried cotton seed to remote regions, so that many of the primitive tribes have obtained commercial cottons which now are variously hybridized with the native kinds. In addition to the principal commercial species and their numerous varieties, there undoubtedly are hundreds, if not thousands, of appreciably different forms of cotton in cultivation among the primitive tropical peoples of both hemispheres.

The conditions of existence for cotton plants no doubt were profoundly changed during the agricultural period of human development, in prehistoric times. With the spread of the primitive agricultural people over the tropical world, the forest areas were restricted and the

species of cotton that previously had been isolated were brought together and allowed to hybridize.

From the fact that cotton is not tolerant of shade, it may be inferred that the species were limited in their natural distribution to dry districts where other vegetation was sparse and open, either because the soil was too rocky or too sandy, or because the rainfall was too limited or too irregular to support large trees or a dense growth of forest. There may have been many separate areas where different wild species of cotton existed, and a few may still exist under conditions of natural isolation, like other wild plants.

How many species there were, before the agricultural period, it may be impossible to determine, or to establish definitely the original associations of the characters. The recognition of species necessarily is provisional in our present state of knowledge, but at least the differences that exist should be recognized, and the out-standing peculiarities that appear in the cotton plants of different regions should be recorded, as affording the best prospect of associating the characters correctly.

Although most of the West-Mexican cottons are to be associated with Watt's Section IV on account of the smooth seed, other characters are remote from those of the Sea Island series. These differences include the presence of distinct angular teeth on the calyx, in some cases produced into slender points, that may even project beyond the buds.

Another departure from the Sea Island series is in the form of the leaves, with the auricles very large, the sinus often completely closed and the lobes overlapping. In these respects there may be more affinity with some of the species of Watt's Section III, species with fuzzy seed and free bracts. Yet these Mexican cottons may be associated with the Sea Island series in the broadest sense, since their seeds are fuzzy only at the base and their bracts are somewhat united.

KEY TO MEXICAN COTTONS

Outer nectaries located on the pedicel, below the receptacle, forming a narrow groove on a longitudinal ridge; large leaves of uprights with broad flat lobes, the margins often distinctly undulate
Gossypium hypadenum

Outer nectaries located on the receptacle, in the sinus of the bracts; leaf-margins not undulate.

Involucres open at the angles, the bracts small, oval, narrowed at the base, not auricled; pedicels swollen at the base, often slender, attaining more than 3 times the length of the mature bolls; fruiting branches short, usually of 1 or 2 slender internodes
Gossypium patens

Involucres usually closed at the angles; bracts cordate, auricled or expanded at the base, below the point of attachment; pedicels stout and short, seldom exceeding the length of the boll.

Bolls flat-sided, square or pyramidal, with no oil-glands over the sutures; the locks held compactly in the open bolls by numerous fibers attached to the carpel walls
Gossypium contextum

Bolls rounded in section; oil-glands not interrupted over the sutures; the cotton not held in the open bolls by fibers attached to the carpel walls

Plants producing a vegetative and a fruiting branch from most of the nodes on the upper part of the stalk; these vegetative branches horizontal, bearing many short fruiting branches; flowers white with large red petal-spots; bolls smooth, oblong-elliptic with a short abrupt beak.....*Gossypium dicladum*

Vegetative branches confined to lower nodes, large and ascending as secondary stalks; flowers white, with no petal-spots; bolls distinctly pitted, conic-ovoid, with a long *acuminate point*.....*Gossypium morrilli*

Gossypium hypadenum, new species

Plants with strong, upright shoots attaining a height of about 10 feet in the first season. Very young stems and margins of the bracts slightly pilose, but all adult parts appearing entirely naked.

Leaves of rather thin papery texture, light green, glabrescent, deeply cordate and auricled, entire or with 3 to 5 broadly triangular lobes, with long acuminate points, side lobes usually very short, often represented only by a tooth; callus red, even on young leaves; petioles held in erect or strongly ascending positions and at smaller angles to the blade than in other cottons; upper side of petiole with a sharp median crest or angle, more distinct on the upper pulvinus, but running well down. Leaves of the upright shoots attaining large size, with the margins undulate, or ruffled, contrasting with the flat surface; length of blade on midrib 17 cm., on the auricles 22 cm., width 24 cm., petiole 24 cm.; auricles very large, often overlapping. Leaf nectaries usually 3, those on midveins much farther up, often twice as far as those on the veins of the forelobes; stipules large and persistent.

Involucral bracts large, flat, deeply cordate and auricled, with 7 to 9 large, gradually tapering teeth, longer than the body of the bract; auricles regularly united on the margins at base almost to their full width; color of bracts light fresh green, sometimes reddened on the exposed side; bractlets not found; outer nectaries, a long narrow groove, simulating leaf nectaries, and located far down on a ridge of the pedicel, rather than in a depression of the receptacle; inner nectaries broadly triangular; no distinct swelling of the receptacle around the end of the pedicel as in the usual cotton types, where the nectaries usually are placed, but a gradual tapering down from the bolls, more like *Gossypium davidsonii;* calyx with long slender teeth, tailed, often exceeding the bud.

Flowers pale yellow, with no petal spots; stamens relatively few, with rather long filaments, anthers brownish, pollen very pale; stigma only slightly exserted.

Bolls rather small, elliptical, acuminate, 3-locked, with a band free of oil-glands along each suture, most of the oil glands being close to the fissures.

Type in the U. S. National Herbarium, no. 1,209,604, collected at Los Mochis, Sinaloa, Dec. 16, 1925, by O. F. Cook and J. W. Hubbard.

Gossypium patens, new species

A large branching shrub or small tree about 12 feet high, with trunk 3 or 4 inches in diameter. Fruiting branches short, practically one-jointed, the other joints very slender and seldom producing bolls. Usually the second joints diverge very strongly from the direction of the first on account of the swollen base of the pedicel.

Leaf forms showing a wide range of diversity; the large leaves of rather heavy texture, several inches across, of broad Upland forms; small leaves having distinct, somewhat attenuate lobes, suggesting Durango or Acala; also many simple, entire, subcordate leaves much like those of *Gossypium davidsonii;* petioles relatively short on the large leaves; stipules of vegetative branches long, linear, those of fruiting branches much shorter and broader.

Involucres small and open, the bracts oval, distinctly narrowed at base, flared at the angles; teeth 5 to 7, well forward, often none below the middle; bractlets usually present, double involucres of frequent occurrence; outer nectaries distinct, but small and uncolored, forming deep, round or short elliptic depressions in the strongly inflated surface of the receptacle; inner nectaries transverse, located in very deep grooves; pedicels often very long, 3 or 4 times the length of the boll, and with the base swollen as in Thurberia; some of the short pedicels much thicker than the internodes of the fruiting branches; calyx lobes with long attenuate tips often exceeding the bud, all five lobes tailed or only 3, with the others sharply angled.

Flowers white, no petal spots; stigma well exserted.

Bolls small, subrotund, abruptly apiculate, 2, 3, and 4 locked, usually 3; fissure deeply marked below, even in green bolls, extending completely to the receptacle; ripe open boll 3.5 cm. across, with beak about 5 mm. long, very distinct in dried state; seeds 4 or 5 in each lock.

Seed small, black, naked, except a small tuft of brown fuzz at beak; lint sparse, fine, silky, more than 1 inch in length, commonly $\frac{1}{2}$.

Type in the U. S. National Herbarium, no. 1,209,601, collected at Guaymas, Sonora, Dec. 8, 1925, by O. F. Cook and J. W. Hubbard.

Gossypium contextum, new species

A robust, spreading, bushy plant, with rather strong short-jointed stalks, hirsute branches and dense foliage.

Leaves heavy, deep green, densely pilose, entire or 3 to 5 lobed, deeply cordate and auricled, sinus often closed; an occasional tooth on the midlobe, or on the basal curves; leaves of the upright shoots attaining large size with very large auricles, often overlapping widely; length of blade on the midrib 20 cm., on the auricle 25 cm., width 27 cm., petiole 24 cm.; nectaries usually 3, even on rather small leaves; stipules present, but not prominent.

Involucral bracts deeply cordate, with long teeth, auricles united at the base; bractlets of common occurrence, often 3 together, usually 3 or 4 to an involucre; calyx with long triangular lobes, sometimes with tails as long as the bud.

Bolls of medium size, short and flat sided, pyramidal or square, with a short abrupt tip; oil-glands not present on a broad light green band over the suture; 3 or 4 locks, with 5 to 7 seed per lock.

Seed dark brown, smooth, with yellowish brown fuzz at base; lint rather sparse, from three-fourths to seven-eighths inches long, easily pulled from the seed, but strongly held in the locks by numerous fibers attached to the carpel walls.

Type in the U. S. National Herbarium, no. 1,209,602, collected at Los Mochis, Sinaloa, December 16, 1925, by O. F. Cook and J. W. Hubbard.

On account of the numerous fibers attached to the walls of the carpels; the open bolls of this species have a distinctive appearance, with the locks not emerging from the carpels, but somewhat drawn down from the opening and remaining a compact mass. This is in striking contrast with the behavior of the cotton in the open bolls of other species. In some cottons the locks remain in place, on account of the rough elastic fibre which "fluffs" and holds together. In other species the locks fall out soon after the bolls open, or the seeds separate gradually.

Gossypium dicladum, new species

A large, upright, densely foliated plant, with woody stems and hirsute leaves and branches, producing small horizontal vegetative branches from most of the joints to near the top of the plants, from the same nodes with the normal fruiting branches, and of about the same size, bearing bolls on small secondary fruiting branches, usually of 1 or 2 joints.

Leaves of medium size, cordate, entire or 3 to 5 lobed, with large forelobes nearly equal to the midlobe; length of blade on midvein 12 cm., on auricle 15 cm., width 18 cm., petiole 13 cm., extra teeth occasional on basal lobes, none on midlobe; auricles ample, often overlapping; texture rather heavy, brittle; nectaries usually one, near the base; stipules prominent and persistent on the young shoots.

Involucral bracts large, cordate, with rather large teeth, the auricles regularly united on the margins below to almost their full width; nectaries usually present; receptacles prominent and distinct; calyx with short sharp pointed lobes, but not tailed.

Flowers large, white, opening widely, with very large dark red spots on the claws of the petals; stamens numerous; anthers pale; stigma barely protruding beyond the staminal column.

Bolls oblong-elliptic, apiculate, 3 and 4 locked; oil-glands large and scattering; no distinct sutural bands without oil-glands.

Seed large, black, naked, except a tuft of greenish fuzz at beak; lint sparse, three-fourths to seven-eighths inches in length.

Type in the U. S. National Herbarium, no. 1,209,605, collected at Los Mochis, Sinaloa, December 16, 1925, by O. F. Cook and J. W. Hubbard.

The double branching habit, with a vegetative branch and a fruiting branch produced together from the upper nodes of the stalks, is a consistent and characteristic feature not previously recognized in any of the "tree" cottons. The greater tendency to produce vegetative branches is apparent even where the branches are very small, with only two or three leaves, but commonly they have several joints and produce bolls on short secondary fruiting branches. The vegetative branch as a whole is about the same size as the primary fruiting branch of the same node. A similar tendency to

produce two branches from the same node of the stalk has been recognized in the Kehchi cotton of eastern Guatemala.[2]

Gossypium morrilli, new species

Tall plants bearing numerous long, short-jointed, fruiting branches with 10 to 12 nodes, often maturing bolls at each node, and frequently two bolls from the same node. Some plants very hairy, others notably less, but all distinctly pilose on new growth.

Leaves large dark green, of thin texture, with very broad lobes, strongly up-folded at the sinus; auricles ample, often overlapping on the large leaves; teeth occasionally on midlobes, forelobes and base; length of blade of large leaf, on midrib 15 cm., on auricle 22 cm., width 21 cm., petiole 18 cm.; leaf nectaries 3, even on rather small leaves; stipules rather large.

Involucral bracts broad, distinctly cordate at base, with inner margins united; bractlets occasionally present; pedicels short, triangular in cross section, but not sharply angled; receptacle distinct, but not much swollen around nectaries; outer nectaries often quite large, usually longer than broad, sometimes narrowed to a short groove; calyx lobes sharp-pointed, often tailed.

Flowers white, of very delicate texture; petals with hyaline areas around the yellow oil glands; stamens with long filaments; stigma slightly exserted.

Bolls small, conic-ovoid, with a long acuminate point, mostly with 3 locks, but often with 4; oil glands large and scattering, not interrupted on sutural bands.

Seed very small, black, naked except a small tuft of greenish brown fuzz at base; lint sparse, about 8 inches in length.

This species was obtained by Dr. Morrill from sand-dunes near the coast of southern Sonora in the Yaqui-Valley district.

Type in the U. S. National Herbarium, no. 1,209,603, collected Dec. 16, 1925, from a plant grown at Los Mochis, Sinaloa, by O. F. Cook and J. W. Hubbard.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

935TH MEETING

The 935th meeting was held at the Cosmos Club on Saturday evening, March 20th, 1926. The meeting was called to order by President BOWIE at 8:15 p.m. with 75 persons in attendance.

The program of the evening consisted of an address by Professor MAX BORN of the University at Göttingen, on *New methods in the quantum theory.*

The Bohr-Sommerfeld quantum mechanics, which since 1915 has been used successfully to find the energy and radiation of an atomic system with not more than one electron, is exposed to the objection that it operates with unobservable quantities such as size of the electron orbit, orbital frequency (which is *not* equal to the frequency of the emitted light), and

[2] See *Weevil-resisting Adaptations of the Cotton Plant*, Bur. Pl. Ind. Bull. 88: 20. 1906.

especially the coordinates p_k, q_k of the electron at a certain time t. A generalized quantum mechanics has been proposed by Heisenberg, attempting to give up this unsatisfactory union of classical mechanics, quantum conditions, and correspondence principle and to replace it by a unique quantum kinematics of discrete energy levels.

That the place of the coordinates p_k, q_k of the moving electrons is taken by matrices of Hermitian type was shown by the speaker in the following way: The Fourier series for the coordinates of the old theory

$$\mathfrak{q}_k = \sum_n A(n) e^{2\pi i n \nu t}; \quad \mathfrak{p}_k = \sum_n B(n) e^{2\pi i n \nu t}$$

are replaced by two-dimensional schemes:

$$\mathfrak{q}_k = \begin{Bmatrix} A(11) & A(12)e^{2\pi i \nu(12)t} & A(13)e^{2\pi i \nu(13)t} & \cdots \\ A(21)e^{2\pi i \nu(21)t} & A(22) & A(23)e^{2\pi i \nu(23)t} & \cdots \\ A(31)e^{2\pi i \nu(31)t} & A(32)e^{2\pi i \nu(32)t} & A(33) & \cdots \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \end{Bmatrix}$$

or in condensed form:

$$\mathfrak{q}_k = (A(mn)e^{2\pi i \nu(mn)t}) \text{ and } \mathfrak{p}_k = (B(mn)e^{2\pi i \nu(mn)t})$$

The coefficients $A(mn)$ are the amplitudes of the wave emitted when the system is jumping from state m to state n, and $\nu(mn)$ is the frequency of this jump, which obeys Ritz's combination principles:

$$\nu(mn) = \nu(mk) + \nu(kn)$$

For the product of two of such schemes we find, since no new frequencies must appear in the exponent:

$$\mathfrak{p}.\mathfrak{q} = (C(mn)e^{2\pi i \nu(mn)t})$$

where

$$C(mn) = \sum_k A(mk)\, B(kn)$$

This is the well-known law of matrix multiplication.

Hamilton's equations must now be written in matrix form:

$$\frac{d\mathfrak{p}_k}{dt} = -\frac{\partial \mathfrak{H}}{\partial \mathfrak{q}_k}; \quad \frac{d\mathfrak{q}_k}{dt} = +\frac{\partial \mathfrak{H}}{\partial \mathfrak{p}_k}$$

while Sommerfeld's quantum conditions

$$\int p_k \, dq_k = n_k h$$

have to be replaced by

$$p_k q_k - q_k p_k = \frac{h}{2\pi i} 1$$

$$p_k q_l - q_l p_k = 0; \; p_k p_l - p_l p_k = 0; \; q_k q_l - q_l q_k = 0,$$

1 being the unit matrix whose diagonal terms are equal to unity while all others are zero.

The general theory of perturbation based on this idea is free from any convergence difficulties, which previously made the application of classical theory of perturbation very ambiguous and questionable.

The speaker then discussed a possible extension of this theory, namely, to replace the matrix calculus by a still more general operator calculus. (*Abstract by O. Laporte.*) The address was discussed by Messrs. HAWKESWORTH, LAPORTE, HERZFELD, and BREIT, and at the close Professor BORN was tendered a rising vote of thanks.

936TH MEETING

The 936th meeting was held at the Cosmos Club on Saturday evening, April 3, 1926. The meeting was called to order by President BOWIE at 8:15, with 45 persons in attendance.

The program for the evening consisted of a paper on *Recent developments in the theory of periodic systems of the elements*, by Dr. OTTO LAPORTE, and was illustrated with lantern slides. The paper was discussed by Messrs. HAWKESWORTH and TUCKERMAN.

Bohr's and Stoner's assignment of total and azimuthal quantum numbers n and k respectively to the electrons of the atoms was discussed with the object of showing that various chemical, physical and spectroscopic evidences suggest subdivision of the ordinary period of eight elements (e.g. Li—Ne, Na—A) into two subgroups of two and six elements; that is, we assume a subshell to be closed with Be, Mg, Zn, etc. Spectroscopic facts show that the electrons belonging to this shell of two have $k = 1$ whereas from B to Ne or Al to A, etc., six electrons with $k = 2$ are bound until the shell is closed again in the rare gases. The apparent irregularity of the first period consisting of but two elements H and He now vanishes immediately, since in H and He two 1_1 electrons are bound, the first period should be compared with the other groups of two and in writing down the periodic chart He must be placed in the second column together with Be, Mg, Zn, Cd, Hg. The thus asserted similarity of the spectrum of He with those of the alkaline earths actually exists. This viewpoint furthermore asserts the inequality of the four valency bonds of the carbon atom, since two of its electrons are bound in 2_1, and two in 2_2 orbits. This fact, although spectroscopically verified in C and the homologous elements Ti, Ge, Sn, still waits for its proof in chemistry.

Of the 18 electrons of A, two are bound in 1_1, 2 in 2_1, 6 in 2_2, 2 in 3_1, and 6 in 3_2. The occurrence of the ten high melting point metals is thus accounted for by the completion of a shell of 10 electrons of 3_3 type and likewise the occurrence of the palladium and platinum metals by 10 electrons of 4_3 and 5_3 character respectively. Similarly the occurrence of 14 rare earths means the binding of fourteen 4_4 electrons. It was pointed out that it is unjustified to write the last three elements Th, Ux, U into the fourth, fifth and sixth columns. One should rather expect here the beginning of a second

rare earth group, characterized by the binding of 5_4 electrons. Whether or not this viewpoint is justified must be decided by investigating their optical and x-ray spectra.

It was finally illustrated how the cabalistic regularity of the periodic system which is contained in the scheme

$$\begin{aligned} 2 &= 2 = 2.1^2 \\ 2+6 &= 8 = 2.2^2 \\ 2+6+10 &= 18 = 2.3^2 \\ 2+6+10+14 &= 32 = 2.4^2 \end{aligned}$$

is explained by means of Pauli's exclusion principle which states that if with one n_k electron the atom is capable of assuming N different orientations in a magnetic field, with two equivalent n_k electrons it can not assume N^2 but only $N\ (N-1)/1.2$ orientations, with three $N\ (N-1)\ (N-2)/1.2.3$, etc. It thus follows that a shell of n_k electrons just contains $2\ (2k-1)$ elements which furnishes the above given scheme. (*Author's abstract.*)

937TH MEETING

The 937th meeting was a special meeting held jointly with the WASHINGTON ACADEMY of SCIENCES and the Biological Survey at the Cosmos Club on Thursday evening, April 15, 1926. The meeting was called to order by President BURGESS of the ACADEMY at 8:15, with about 100 persons in attendance.

On behalf of the American Geographical Society Major Gen. SALTZMAN presented the Charles P. Daly Medal to Brigadier General DAVID L. BRAINARD, and Captain CROSLEY presented the Cullom Geographical Medal to Dr. HARVEY C. HAYES. Major General GREELEY was present and spoke in appreciation of the attainments of General BRAINARD. The recipients accepted the medals with appropriate words of thanks.

The address of the evening was given by Dr. PAUL R. HEYL, on *Visions and dreams of a scientific man.*

H. A. MARMER, *Recording Secretary.*

BIOLOGICAL SOCIETY

690TH MEETING

The 690th meeting was held in the new assembly hall of the Cosmos Club 13 March, 1926, at 8:00 p.m., with President OBERHOLSER in the chair and 68 persons present. New member elected: JOHN P. HOLMAN.

T. S. PALMER reported the death of the female Brazilian cardinal (*Paroaria cristata*) which has spent the winter in the vicinity of the Department of Agriculture and on the Smithsonian grounds. The bird first appeared in September and has been fed regularly through the winter by many people. It was found in a weakened condition and put in a cage, where it died on 24 February. An examination of the body showed filaria and staphylococcus. The only previous record of a bird living here for several months in the wild state is that reported several years by Dr. P. BARTSCH. A. WETMORE spoke of his experience with the bird in Argentina. It ranges south to Buenos Aires, which is not as cold as Washington, although snow sometimes occurs. It is common in the Chaco, and highly esteemed as a cage bird. F. C. LINCOLN reported that one was captured last fall in a bird trap at Indianapolis by a bird bander, who thought it might be a cross between a cardinal and a rose-breasted grosbeak.

PAUL BARTSCH reported that the mockingbird that has appeared at his bird feeding-counter for several years has returned this winter and eats suet for the first time.

JOHN C. PHILLIPS: *Introducing foreign and American birds into new localities* (illustrated by specimens).—Birds introduced into new regions show several types of response to the new environment. (1) They may disappear at once (some game birds and European song birds); (2) they may nest the first season, then quickly or gradually die out without nesting again (Hungarian partridge in the eastern States); (3) they may have a long period of only local success (European goldfinch in Massachusetts and eastern New York, skylark on Long Island and Vancouver Island); (4) they may propagate rapidly and spread into new territory (California partridge in Australia), with increase in size of broods and apparent immunity from natural enemies, but usually ultimately disappear; (5) they may become thoroughly naturalized (English sparrow and starling).

The history of bird importation in this country is little known before the '50's. Cagebird fanciers, particularly near Cincinnati, New York, and Portland, Oregon, and sportsmen have been the two most important agencies in introduction.

Among introduced game birds, all the west American species introduced in the East have failed, as has the Egyptian quail, which bred for one season, and disappeared. Valley quail, plumed quail, and Hungarian partridge have succeeded in the northwestern United States and Canada. Blackcock and capercaillie have failed in the eastern States and Canada. Several tropical species have recently been introduced on Sapelo Island, Georgia. The chachalaca has flourished, but the ocellated turkey has not. Guineafowl, introduced in the West Indies 200 years ago, have run wild and become a good game bird. (*Author's abstract.*)

PAUL BARTSCH, National Museum: *Some experiences with the birds of the Dry Tortugas* (illustrated).—The Tortugas are 68 miles southwest of Key West. This group constitutes one of the National bird reservations and is particularly interesting because here we find the only colony of Sooty and Noddy Terns breeding on the American Coast. Bird Key, a small sandy island only a few feet above sea level, some 400 feet in length and 200 feet in width, harbors annually no less than 30,000 of the Sooty and Noddy Terns. These birds have been breeding here for a long time. They were visited in 1832 by Audubon, and have been the object of attention from naturalists ever since. The Sooty Tern probably breeds there today as it did when first discovered, but the Noddy has undergone a tremendous change in nesting habits in the last decade, owing to the fact that several recent hurricanes have denuded the island of its woody vegetation. When Dr. BARTSCH first visited the group 14 years ago, the Noddy Tern bred in the Bay Cedars which formed an abundant thicket on this Key, and since their destruction they have been forced to abandon this mode of nesting, being slowly forced to the ground by the dying and breaking off of the dead branches of these shrubs. The birds, which were at first tree nesters, now cling to anything that suggests wood, branches of the old stubs of the Bay Cedars or the little branches on the ground pulled together to form a nest. The old boards from a wrecked house, being wood, in part satisfy the craving for a woody nesting site, and where these elements are wanting the Noddy has at last come to use a mere hollow, just as does the Sooty.

It has been an interesting change, which, while gradual during the last 14 years, may, nevertheless, be considered a rather abrupt transition from a tree building type to a ground nester. With this change in nesting habit has come a decided diminution in the numbers of the Noddy, while the Sooty has maintained itself in the usual number.

It is interesting to note that in the single palm tree standing on the island today, the Noddies are breeding in numbers in the axils of the leaves high above the ground.

The Biological Survey has now planted several hundred coconut palms on the island. Most of them are doing well and will furnish, it is hoped, adequate nesting site, as well as shelter from the glaring rays of the sun, to the young birds of both species.

All these transition changes of nesting were illustrated with lantern slides, as well as the home life of both species, likewise of other visiting water birds, such as large numbers of Man-o'-war, and three species of Boobies. Dr. BARTSCH also showed pictures of the breeding colonies of Roseate Terns on Long Key, and of the Common Tern colony on Bush Key, and of some of the other visiting birds, such as waders and herons. He mentioned that so far he had recorded 136 birds from the group, most of which, of course, are spring and fall migrants. (*Author's abstract.*)

S. F. BLAKE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

DR. ARTHUR L. DAY is at present engaged in investigations in California as chairman of the Advisory Committee of the Carnegie Institution of Washington on seismology.

DR. W. S. ADAMS, Director of the Mount Wilson Solar Observatory, was in Washington during the early part of June, on his return from New York, where the degree of doctor of science had been conferred upon him by the Columbia University.

Mr. W. C. Parkinson of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington left New York June 10 for the Huancayo Magnetic Observatory in Peru, where he will act as consultant in the installation of earth-current recording devices.

A lecture on *World migration as illustrated by the distribution of the redwood tree*, was given by Ralph W. Chaney at the Carnegie Institution of Washington, on May 25, 1926.